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COMPLETE SPECIFICATION

Improvements in and relating to Radial Cylinder Pumps and Motors

We, SOCIETE ANONYME ANDRE CITROEN, a French Body Corporate, of 117 and 165 Quai de Javel, Paris, Seine, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a hydraulic machine which is capable of operation either as a positive displacement pump or as a motor.

Positive diplacement pumps are already known comprising a body of a pump with radial cylinders combined with an annular cam, the said cam and the cylinders being actuated in a relative movement of rotation in such a way as to control the alternating movement of pistons sliding in the radial cylinders.

In these known pumps the control of the pistons by the annular cam is effected by direct action of the said cam on the piston by the intermediary of an articulated follower on the head of the piston and rolling on the annular cam.

These known devices have various drawbacks. In particular the reactions of the cam on the follower are equal to the forces applied to the piston and the travel marked out for the follower transmitting the power supported on the cam is equal to the travel marked out for the piston.

The consequence is that there are heavy reactions on the cam and a considerable slip component which detracts from the efficiency of the pump.

The object of the present invention is to remedy these drawbacks.

According to the invention there is provided a hydraulic machine capable of operation either as a positive displacement pump or as a motor, comprising a central body having radial cylinders, a piston arranged in each cylinder, and an annular cam surrounding the central body, the cam and the central body being capable of rotation relative to each other in such a manner as to cause several alternating movements of each piston for each revolution, the movement of each piston being effected by means of an oscillating lever which is in contact with the cam and with the piston, wherein the point of contact between the lever and the cam, and the point of contact between the lever and the piston are so arranged with respect to the axis of oscillation of the lever as to ensure a diminution in stress so that the reactions of the cam on the lever are less than the forces applied to the piston.

Specific embodiments of the invention as applied to a positive displacement pump will nov be described by way of example with reference to the accompanying drawings in which:—

Figure 1 shows, on a large scale, an axial section through the whole pump,

Figure 2 shows a section through the pump along the line II-II in Figure 1,

Figure 3 is a section through part of a roller-carrier through the axis of one of the double follower rollers,

Figure 4 shows a section through the device for adjusting the delivery pressure to the position of the corresponding distributor in relation to the annular cam,

Figure 5 is a sectional view in elevation of another embodiment of the pump.

Figure 6 is a partial view showing the arrangement of the follower rollers of the levers actuating the pump pistons on the annular cam having a double rolling track.

In the specific example selected and illustrated on the drawings, the pump according to the invention comprises essentially a central body 1 pierced by radial cylinders 2, preferably even in number, for the sake of simplicity in machining. This central body comprises a co-axial

recess wherein is mounted and fitted a core 3 in which are provided the cylinder heads 2_1 of the cylinders 2.

This core 3 has tapered surfaces 4, 5 forming conical bearing surfaces for the two members of the distributor, the whole of which is mounted co-axially with the pump body and moves in relation thereto. Sealing rings 6, on each side of the core 3, prevent leakages between said core and the central body.

The central body is supported by bearings 7 mounted on each side of the plane perpendicular to its axis which contains the cylinder axes. It also comprises, on its periphery, shafts 8 parallel to the axis of the bearings about which pivot levers 9 carrying follower-rollers 12, which levers, through balls 10 or the equivalent acting as push rods, engage individually the pistons 11 movable in the central body 1.

The follower-rollers 12 of the levers 9 roll inside a single or double annular cam 13 carried by the casing 14 in which is enclosed the central body 1 and in relation to which the central body moves. Figure 3 shows a cross-section through a cam having a double internal rolling track engaged by double follower rollers. The cam 13 has a certain number of bosses and hollows each of which forms a cylindrical surface the generators of which are parallel to the axis of the bearings of the central body. The curve which characterises the passage from one hollow to the next or from one boss to the next recurs in constant angular rotation. This rotation is equal to 180° if there are 2 hollows and 2 bosses per complete revolution as is the case with an elliptical or pseudo-elliptical cam; more generally, if there are n separate bosses and n separate hollows, the curve recurs each angular rotation of $\frac{2\pi}{n}$ radians.

The driving of each piston by the corresponding oscillating lever 9 is effected as can be seen in Figure 2 between the point of oscillation of the lever and the follower 12 placed at the other end of the lever, and resting on the annular cam 13.

The result is a reduction in the stresses such that the reactions of the follower on the cam are weaker than the forces applied to the piston.

This arrangement also ensures the following technical advantages:—

The path traced by the follower transmitting the power by resting on the annular cam is greater than the travel traced by the movable pistons in the cylinders of the pump.

The use of the balls 10 prevents practically any lateral stress of the pistons in their respective cylinders and consequently the heating and wear which would result therefrom.

When the machine is acting as a pump for delivering liquid under pressure, the said pistons 11 move from the outside towards the axis of the central body during the period of delivering the liquid and from the axis towards the outside of the body when the liquid is sucked into the cylinders. When the machine is acting as a hydraulic motor, the liquid under pressure is admitted to the cylinders when the pistons move from the inside towards the outside while the evacuation of the liquid to the reservoir 31 takes place during the reverse movement of the pistons.

The distributor mounted co-axially with the pump consists of two members 15 and 16 allocated respectively to the admission and delivery of liquid when the machine is acting as a pump. These members rest against the conical bearing surfaces 4 and 5 of the central core 3.

The ports 17 and 18 are bored in the central core and by means of corresponding ports 17_1, 18_1 formed in the distributor members, the cylinders are brought into communication alternately with the suction pipe 19 and the delivery pipe 20, which are connected to the distributor.

Although the ports 17, 17_1, 18, 18_1 are illustrated in simultaneous coincidence in the case of the cylinder 2 on Figure 1, it will be obvious that in practice such a simultaneous coincidence never occurs because in this case the high pressure and the low pressure would be by-passed by means of said cylinder. It should be understood that it is a question of two different sections, one relating to the half distribuor on the right, the two sections in question being brought into the same plane as the figure.

The cylinder heads 2_1, as well as the corresponding ends of the pistons 11 are also conical in shape, the apex facing the axis of the central body 1, which, on the one hand reduces the path of the liquid through the distribution ports 17, 18, and on the other hand reduces to the minimum possible value the dead volume at the end of the compression stroke.

In the distributor constituted as indicated above, the two members 15, 16 are held applied against the conical bearing surfaces 4 and 5 of the central bore 3 by the delivery pressure of the pump. The adjustment of the clearances and the compensation for wear and expansion are thus obtained automatically by the relative displacement of the two distributor members. For this purpose one of the members of the distributor has a hollow cylindrical extension 16_1, constituting the delivery pipe 20, which is housed within the other mem-

ber of the distributor. The extension 16_1 communicates *via* an orifice 100 (Figure 1) with an annular chamber 21 having mutually slideable end walls one of which is rigidly connected to the member 16 of the distributor, and the other of which is rigidly connected to the member 15 of the distributor.

The cylindrical extension 16_1 communicates with the cylinder heads 2_1 by means of the distribution ports 18, 18_1 and is thus traversed by the delivery liquid, which passes through the orifice 100 into the annular chamber 21. The flow pressure thus acts to separate the walls of the annular chamber 21 in such a manner as to move the distributor members 15, 16 towards each other. The two members 15, 16 are therefore applied by a suitable pressure on the intervening bearing surfaces 4 and 5 of the central core.

The members 15 ,16 of the distributor, which are allocated individually to the high and the low pressure, can be adjusted relatively to one another, so as to ensure the optimum filling of the cylinders and the optimum reduction in the effects of compressibility.

The orifices 17_1, 18_1 provided on each member of the distributor for the admission of the liquid or for its discharge from the cylinders in the central body, are uniformly distributed round the periphery of each of the said members in a number equal to the number of bosses or hollows encountered on the rolling track in one complete revolution.

Advantageously, one of the distributor members can be fixed in relation to the annular cam 13 rigidly connected to the casing 14, while the other distributor member is capable of limited angular displacement to permit the correction of the effects of compressibility at variable pressures. This correction device is illustrated on Figure 4. It comprises essentially a cam 22 subject to the action of a resilient member, for example a torsion bar 23 on which the said cam is mounted. A push-rod 24 subject to the delivery pressure, acts on the cam 22 to modify its angular position. The displacement is limited by adjustable stops such as 25. The cam 22 forms a stop for a roller lever 26 rigidly connected to the extension 16_1 of the movable member 16 of the distributor.

When in operation, the friction of the movable member 16 of the distributor on the central core 3, tends to apply the follower roller 26′ of the lever 26 against its cam 22. Nevertheless a spring 27 may be added to urge the roller 26′ of the lever 26 against its cam 22. Since the position of the cam 22 is dependent on the delivery pressure, it will be understood that the angular position of the movable member 16 of the device adapts itself automatically to changes in pressure difference between the delivery side and the suction side of the pump, the latter pressure being fixed by an adjustable valve.

By way of modification, it would also be possible to use twin cams instead of a single cam 22 in order to guide the follower which would then comprise two rollers arranged one on each side of the lever 26.

In view of the very small dead volume the setting of the distributor member allocated to the low pressure side is fixed in relation to the rolling track carried by the casing, in the case of operation as a pump.

Finally, in the specific embodiment illustrated, the pump comprises an auxiliary feed pump or force-feed pump 28 driven by means of bevel pinions 29 from the driving pulley 30. This pump comprises a calibrated delivery valve (not shown), and is arranged to take up liquid from the reservoir 31 and inject it at a particular pressure, corresponding to the setting of the valve, to the low-pressure side 15 of the distributor through the pipe 19 to avoid any cavitation phenomenon during high-speed running or any risk of running dry.

OPERATION OF THE PUMP.

In the case of the example illustrated, the operation of the pump is obtained by the rotation of the central body 1 and of its pistons in relation to the casing 14 and the annular cam 13 rigidly connected to the casing, and in relation to the distributor 15, 16.

This rotation is obtained from the pulley 30 by means of the shaft 32.

During this rotational movement of the pump body 1, the levers 9, of which the follower rollers 12 rest on the rolling track of the annular cam 13, drive the pistons 11 towards the centre, that is to say towards the cylinder heads, each time they pass over a boss on the annular cam 13.

The resting of the follower rollers 12 on the annular cam 13 and the return of the pistons associated therewith, is effected by centrifugal force if, as in the example in question, the central body is in rotation, or by the pressure of the force-feed pump if it is the casing and the annular cam associated therewith which are in rotation in relation to the central body assumed to be fixed. In short, in the case of the rotation of the central body and of a not inconsiderable delivery pressure from the force-feed pump, it is the above-mentioned effects which are superimposed to keep the pistons in contact with the roller-carrying levers and to maintain the contact between the actual rollers and their rolling track.

Figure 5 shows another specific embodiment of a pump which, like the one de-

scribed above, comprises a central body 1 pierced with radial cylinders 2, the heads of which are provided in an inserted central core 3. Co-axially with this central core is mounted the two-part distributor assembly 15, 16, as described above. In the radial cylinders 2 slide pistons which are engaged by levers 9 articulated on the body 1 of the pump and having rollers 12 which rest on a double-track annular cam 13 (Figure 6). This cam comprises a web 13_1 which is gripped between the two portions of the casing of the pump.

The pump body 1 comprises an odd number of radial cylinders 2, for example 5, as in the example illustrated. This body is surrounded by the annular cam 13 which also comprises an odd number of bosses and hollows, said number being different from that of the cylinders. It is three in the example shown. This arrangement makes it possible to reduce very effectively the shocks in the delivery and all the disadvantages resulting therefrom (noise, loss of efficiency etc.) by regularisation of the flow while avoiding serious reactions on the shaft because of the considerable number of pulsations.

Furthermore, in the example shown, the pistons 11 engaged in the radial cylinders of the pump body are engaged by means of push-rods 50 resting, by means of knife-edge articulations 51, against the articulated control levers 9. These push-rods also rest on the pistons by means of a ball 52. The assembly permits the lateral stresses on the cylinders by the pistons to be reduced and consequently the wear to be reduced. Moreover, it would be an advantage, with a view to reducing the friction, to mount the rollers 12 on ball bearings or needle-roller bearings.

WHAT WE CLAIM IS:—

1. A hydraulic machine capable of operation either as a positive displacement pump or as a motor, comprising a central body having radial cylinders, a piston arranged in each cylinder, and an annular cam surrounding the central body, the cam and the central body being capable of rotation relative to each other in such a manner as to cause several alternating movements of each piston for each revolution, the movement of each piston being effected by means of an oscillating lever which is in contact with the cam and with the piston, wherein the point of contact between the lever and the cam, and the point of contact between the lever and the piston are so arranged with respect to the axis of oscillation of the lever as to ensure a diminution in stress so that the reactions of the cam on the lever are less than the forces applied to the piston.

2. A machine as claimed in claim 1, wherein on each lever, the point of contact with the annular cam and the driving point of the piston are positioned on the same side of the lever in relation to the axis of oscillation.

3. A machine as claimed in claim 1, wherein a roller follower is interposed between each lever and the annular cam.

4. A machine as claimed in claim 1, wherein each of the pistons sliding in the radial cylinders is driven by the intermediary of a push-rod articulately supported on a knife-edge bearing on each lever.

5. A machine as claimed in claims 1 and 2, wherein a ball is interposed between each lever and piston in order to reduce the lateral stresses on the cylinders and the pistons.

6. A machine as claimed in claim 1, wherein the distributor comprises two elements, respectively for the admission and the discharge of the fluid, said elements preferably resting against conical bearing surfaces of the body of the pump or of its central core.

7. A machine as claimed in claim 6, wherein the distributor is acted on by the liquid pressure so that it is pressed against the central core of the body of the machine, thus reducing the possibility of leakage between said body and the distributor.

8. A machine as claimed in claim 6 or claim 7, wherein one of the distributor members is formed with a cylindrical extension which passes through the other distributor member, and wherein there is provided an annular chamber having mutually slideable end walls each of which is rigidly connected to one member of the distributor, in which chamber the flow pressure acts to separate said end walls in such a manner as to move the distributor members towards each other.

9. A machine as claimed in claim 8, wherein one of the distributor elements is fixed at an angle to the annular cam while the other can be angularly displaced to a limited extent, which allows the principal effects of compressibility at varying pressures to be corrected.

10. A machine as claimed in claim 9, wherein the correction rotation of the element of the distributor which can be displaced angularly to a limited extent, is controlled by means of a cam operated by the action of a resilient medium, such as a torsion bar, and a push-rod on which there acts in the opposite direction a piston acted on by the liquid pressure, and by means of a control lever, having a cam follower, rigidly secured to the movable element of the distributor.

11. A machine as claimed in claim 10, wherein the friction of the movable element

of the distributor on the central core tends to press the follower of the control lever onto the cam.

12. A machine as claimed in claim 10, wherein a spring returns the follower of the control lever onto the cam.

13. A machine as claimed in claim 10, wherein the follower of the control lever comprises two rollers arranged one on each side of the control lever, which rollers are guided between two twin cams arranged opposite one another.

14. A hydraulic machine substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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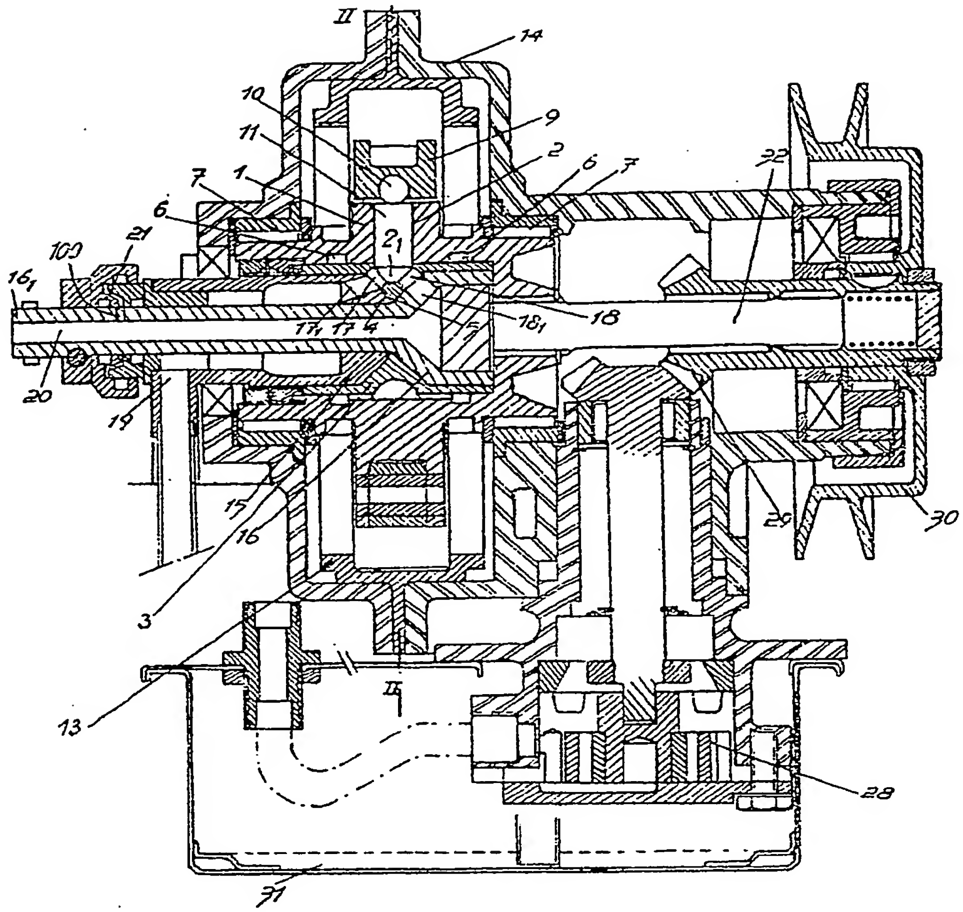


Fig.1

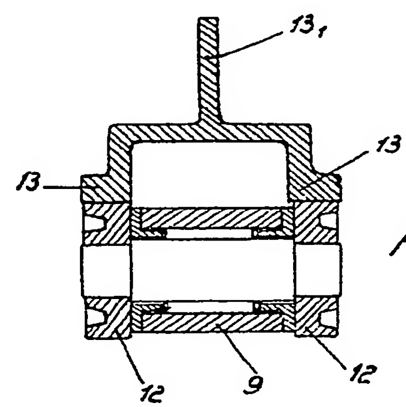


Fig. 6

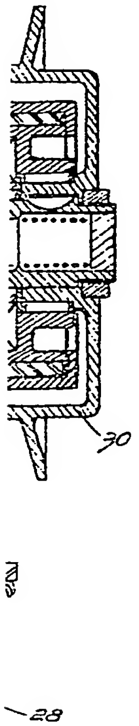
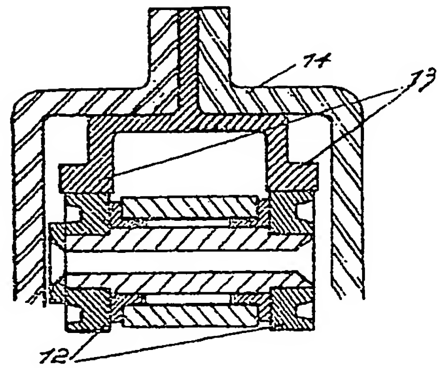


Fig.3



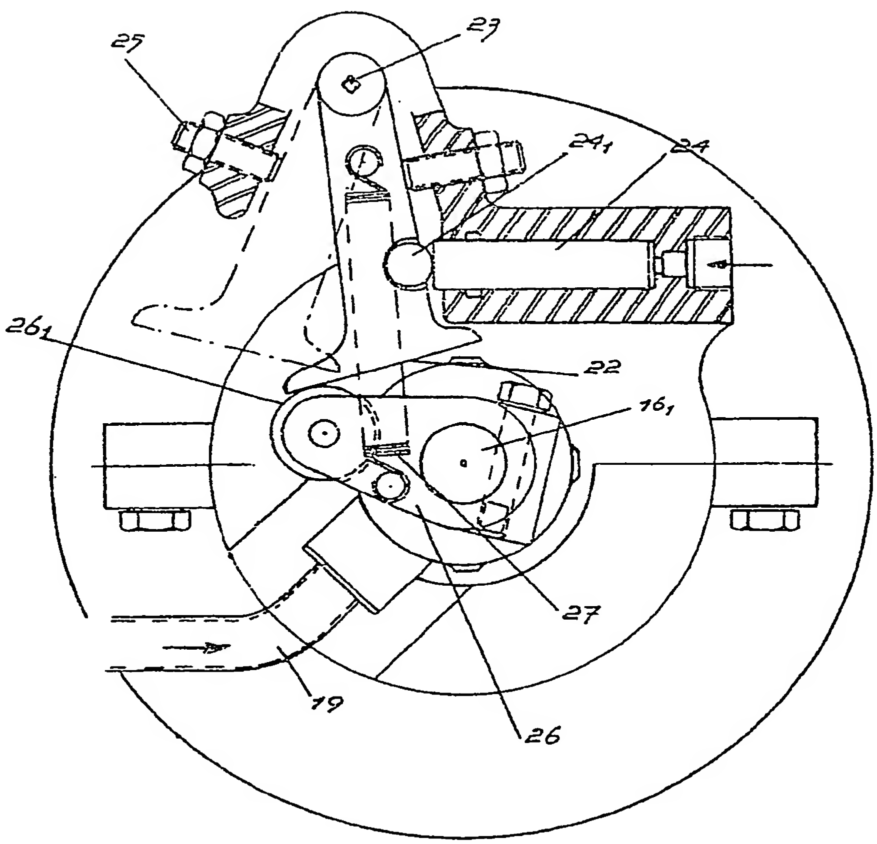


Fig. 4

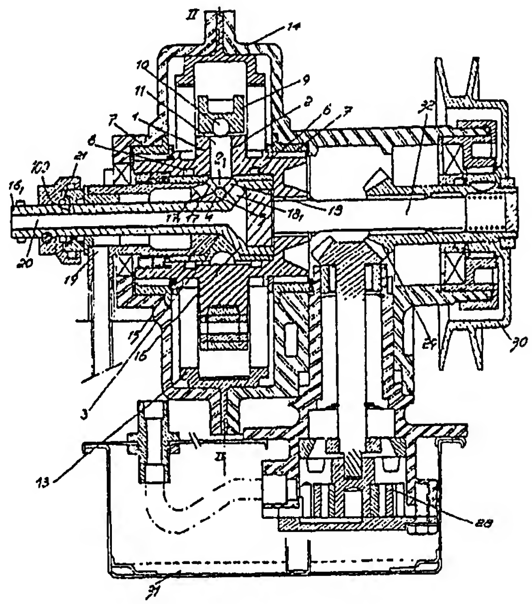


Fig.1

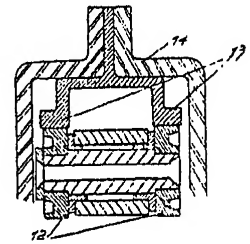


Fig.3

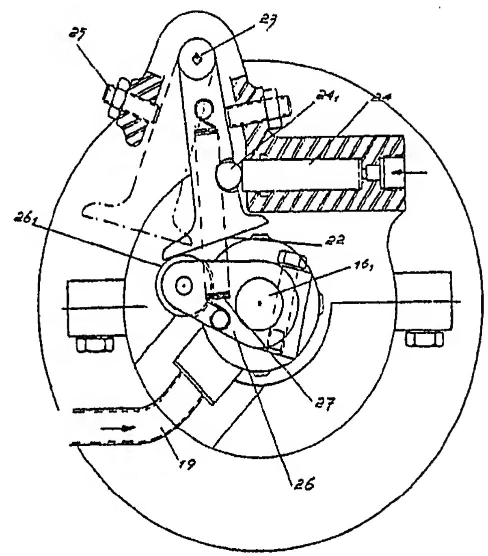


Fig.4

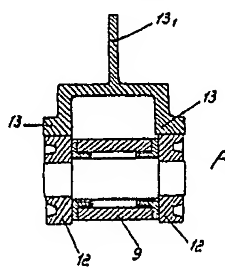


Fig.6

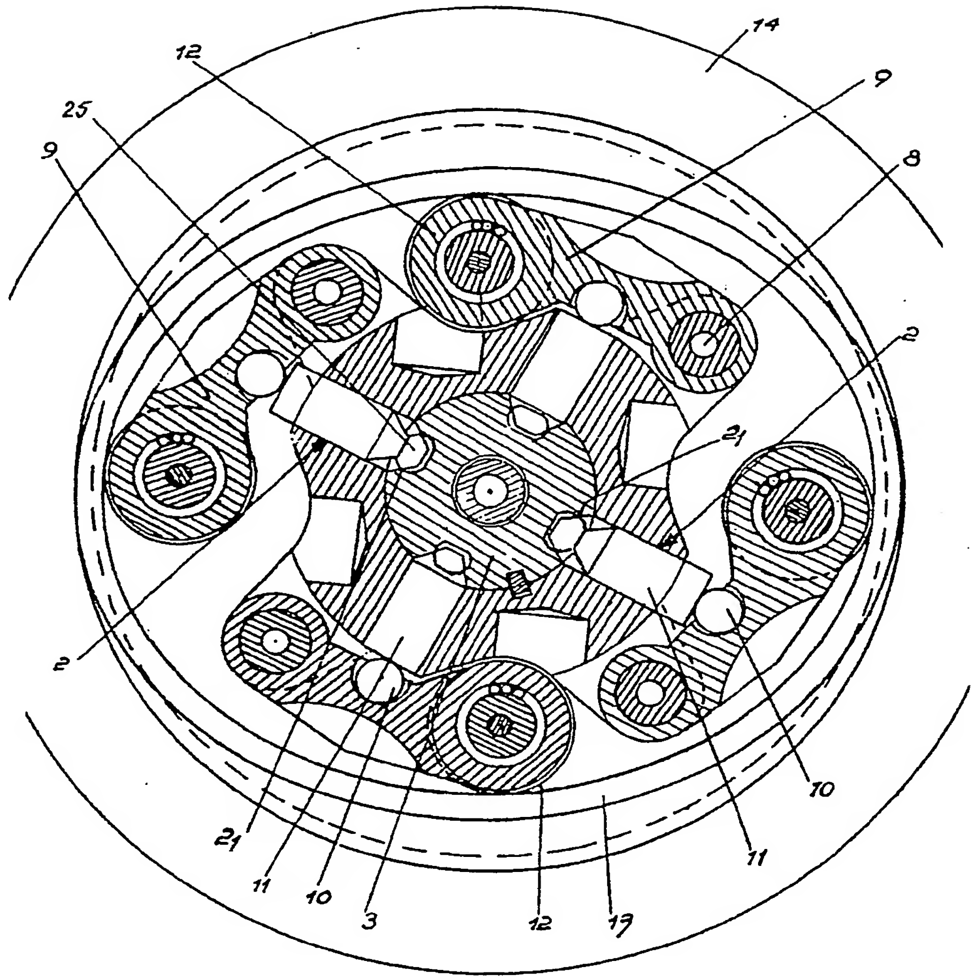


Fig.2

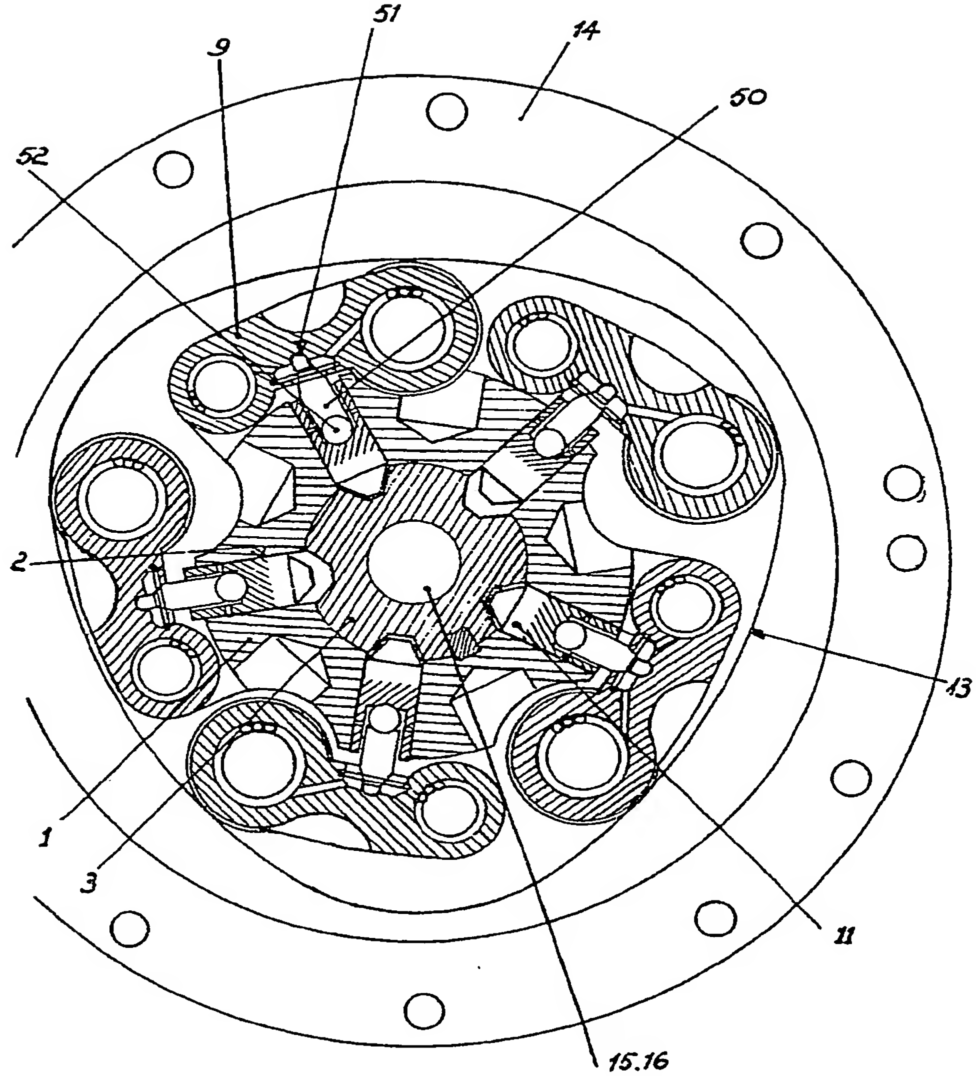


Fig. 5

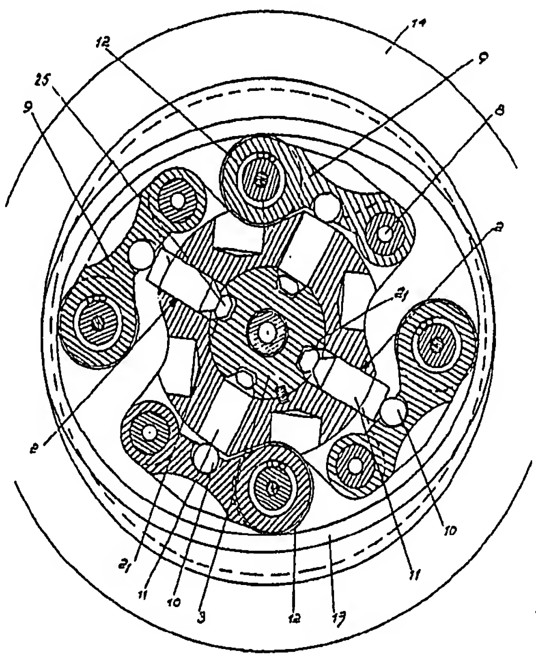


Fig.2

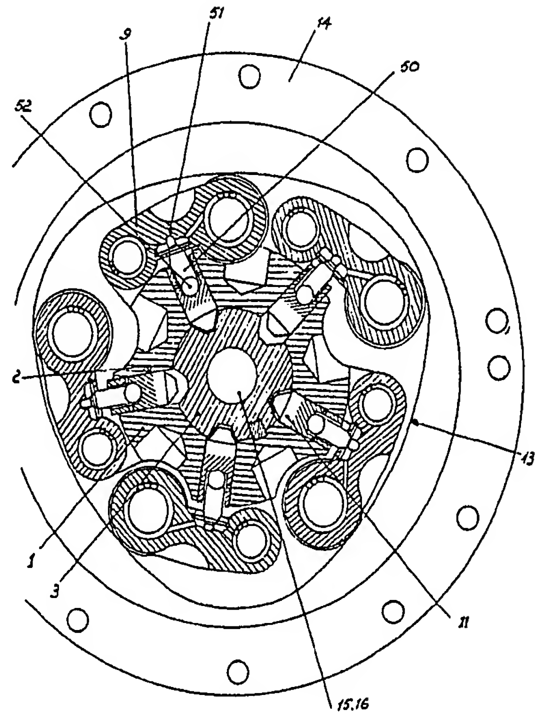


Fig. 5